CORPORATE-TECH PLANNING INC.

SCHEDULING STANDARDS PILOT PROJECT

conducted at

PETERSON BUILDERS, INC.
STURGEON BAY, WISCONSIN

Sept 1981 through April 1982

--- SUMMARY REPORT ---

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EXECUTIVE OVERVIEW

This seven-month project tested the application of scheduling standards in a shipyard pipe fabrication shop. Actual hands-on data was accrued, analyzed, and applied during three separate testing periods. Results show that fabrication manhours were reduced by about one-third, permitting the fabrication of about 50% more pipe with the same number of fabricators. The key to success is the scheduling standard, developed from engineered labor standard data plus a factor to accommodate non-process considerations. The scheduling standard accurately predicts REAL work content, allowing the major improvements in work loading, planning, and scheduling from which the savings result.

CORPORATE-TECH PLANNING INC

SCHEDULING STANDARDS PILOT PROJECT
SUMMARY REPORT

I. BACKGROUND

The National Shipbuilding Research Program is funded by the Maritime Administration, United *states* Department of Transportation, toward improving productivity in shipbuilding. Technical direction of this Program is provided by the Ship Production Committee of the Society of Naval Architects and Marine Engineers. The Ship Production Committee is composed of several Panels, one of which is the Panel on Industrial Engineering, SP-8. The Industrial Engineering Panel and the Panel on *standards* (SP-6) make-up the ship Producibility Research program, managed by the Bath Iron Works Corporation, Bath, Maine.

Industrial Engineering Panel SP-8 was activated in 1978, and has been carrying out two major research efforts: (2) the development of engineered labor standards, and their application for (a) methods engineering/*improvement* and (b) planning and scheduling shipyard work; and (2) generally increasing industry awareness of industrial engineering potential. During the past two years, much standard data has been accrued through the use of MOST* in several participating shipyards, among them Peterson Builders Inc., Sturgeon Bay, Wisconsin where standard data has been produced in the fabrication pipe shop area.

Although several participating shipyards have made advances in methods engineering/improvement using standard data, none had tried to apply these data for planning and scheduling purposes until the Scheduling Standards Pilot Project described in this Summary Report.

*Maynard Operational Sequence Technique.

II. INTRODUCTION

This Project was initiated as a result of consensus opinion gained at the SP-8 meeting held at Portsmouth, NH on 24-25 June 1981. The Project would try out the application of scheduling standards for planning/ scheduling *purposes. Data gained from the* Project would be available to assist in defining the Phase III Data Application portion of the continuing industrial engineering program under SP-8.

The project was conducted *generally in* accordance with a technical proposal submitted by Corporate-Tech Planning Inc. (Rodney Robinson) to Bath *Iron Works* on 28 Aug 1981. Bob Graves (U. Mass.) and Leon McGinnis (Georgia Tech.) carried out a related and supporting project to analyze the data collected. LOU *Kuh* (H.B. Maynard Co.) provided input in the form of MOST standard data. Shipbuilder input was provided by personnel from Peterson Builders, Inc., (Gary Higgins, Dan Kressig) where the Project was carried out. Overall direction was provided by a Steering Committee composed of representatives of the above activities, plus the SP-8 Project Office at BIN *(Joe Fortin).*

This Summary Report describes the principal features and findings of the Project.

DURATION: September 1981 through April 1982

LOCATION: Pipe Fabrication Shop, Bldg. 70
Peterson Builders, Inc.

DEFINITIONS UNIQUE TO THIS PROJECT:

Work Order - the document used at PBI to describe a package of piping fabrication work.

Pipe Detail - an individual sheet of a work order describing the details of a single pipe detail or spool piece. A typical work order would *contain several* pipe details.

Estimate - an assessment of the work content of a work order made by planning peopl e at PBI based on the requirements of the work order and historical return cost data for similar work on previous hulls.

Return Cost - the charges for a *work order taken* from the usual PBI charging system, consisting of a periodic computer runoff of time card entries.

Time Sheet Hours - charges taken from special data sheets filled out by the mechanics themselves at the workplace; Time sheets were used during this Project to provide timely and accurate charges *for the work* under test, by individual pipe detail. Although it took some time for each mechanic to fill out his data sheet, the disruption and delay involved were minimal and can safely be ignored.

Process Time - the time spent by the mechanic in carrying out the basic *process (fitting,* grinding, welding, bending, sawing, etc.).

Non-process Time - the time spent by the mechanic while engaged in activities outside of the basic process (personal time, waiting for material, readiig work instructions, equipment breakdown delays, crane delays, etc.).

Non-process Factor - a factor developed by the Project team to take into account the real, natural, and acceptable differences between level times and actual times for accomplishing work. The magnitude of the non-process factor was based on work sampling conducted by PBI personnel at the workplace.

Scheduling Standard - an engineered labor standard consisting of two parts: (1) the usual best performance portion based on standard data from MOST, called level time; and (2) a calculated non-process factor, developed to accommodate real-world considerations surrounding conduct of the work. The scheduling standard (level time increased by the non-process factor) is a realistic prediction of actual “will cost” charges for the work, under the circumstances currently existing at tbe work place.

III. GENERAL APPROACH

The general approach to this Project, developed by Corporate-Tech and approved by the Steering Committee, included the following steps;

- Obtain MOST data for a selected group. of work orders, and deternine level times for doing the work.

- Conduct work sampling to determine process time and non-process time fractions. (Work sampling also provides detailed insight into both. categories.) Take five minute work observations once each hour for each two-week testing period. Determine the percentage of time mechanics were carrying out the basic process (called the process time fraction), and the percentage of time the mechanics were engaged in non-process activities (called the non-process fraction).

- Calculate a non-process factor. Basically,

$$\text{Non-process factor} = \frac{\text{non-process time fraction}}{\text{process time fraction}}$$

- calculate scheduling standard hours (level time increased by the non-process factor.)

  Sch. Std. Time = Level Time + (Level time x non-process

  or,

  Sch. Std. Time = Level Time (1 + non-process factor)

- Determine the actual costs for the work.

- Analyze data to see whether scheduling standard predictions match actual costs.

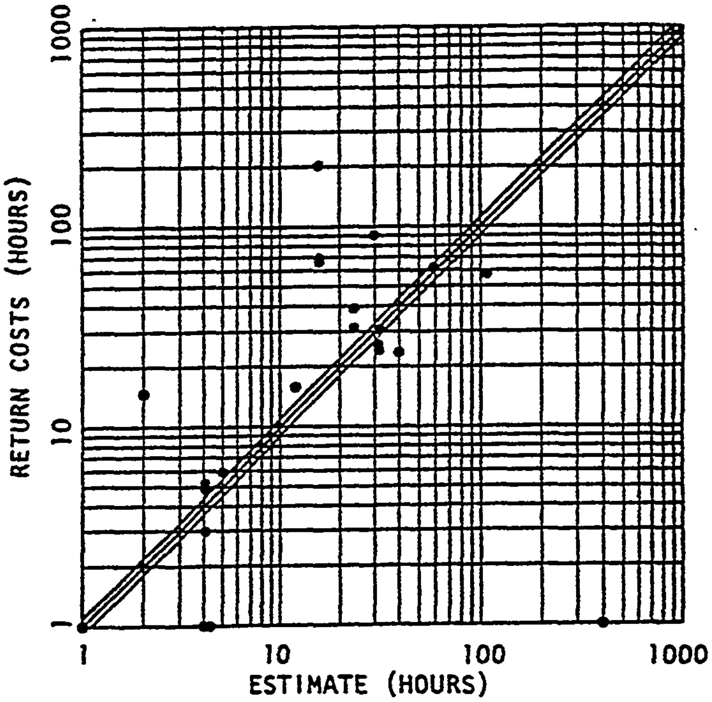
- when prediction capability is established, load the shop using scheduling standard hours and see if benefits accrue.

IV. BASELINE DATA

The following data reflects conditions at PBI immediately pries to the start of Project testing.

- pipe fabrication work orders typically ran between 5 and 400 manhours each, as estimated by the planning people at PBI, with an average work order estimated at about 40 manhours.
- The workforce in the pipe fabrication shop varied from 5 to 10 mechanics.
- About 2-weeks worth of work (by work order estimates) was loaded on the shop at one time.
- A work order was usually assigned to one mechanic who performed work in the same order that the pipe detail sheets were assembled into the work order.
- A single ground rule was given to the mechanics in the fabrication pipe shop prior to data collection for this Project. That rule was for them to perform the same way that they had in the past. They were asked not to work any harder, any less hard, or any differently than was their usual practice, nor should they change any work methods or procedures just for this Project. The reason for this groundrule was to permit the CAPTURING of normal mechanic performance. Certainly, actual working periods might become more frequent as the Project matured, but the mechanics were asked to work at their usual intensity when they worked.
- Previous performance on-typical, randomly selected work orders shows wide scatter between estimated hours and return costs (Figure 1)*. The data points are spread out on both sides of the diagonal. (When return costs <u>match</u> the estimates, the data points are on the diagonal. When

*Scatter diagrams in this report are plotted on log-log paper to provide a reasonable spread of data points. The band on either side of the diagonal is ±10% wide.



BASELINE DATA

FIGURE 1

return costs are higher than the estimates, data points are above the diagonal; when return costs are lower than the estimates, data points are below the diagonal). The wide scatter indicates poor correlation between individual estimates and returns, which argues that historical return costs are not a good basis for estimating the future cost of similar work orders. Note that in the aggregate, however, total return costs essentially match the total estimated hours for this sample of work. This fact is quite normal in shipbuilding, where actual charges often rise to match the budget (estimate) available. (See Reference a).

V. TESTING PERIOD

Three testing periods were *carried out.*

<u>First Testing Period</u> - 30 Sept 1981 through 23 Ott 1981

- Purpose was to determine the prediction capability of scheduling StandardS.
- Eight *work* orders in sample, ranging in estimated size from 4 to 400 manhours.
- Level times obtained from detailed MOST, and also from a classification scheme based on detailed MOST data. Reference (b) describes in detail the development of the classification scheme used.
- Three pages from reference (b) showing typical classification charts are included here as Appendix *A. Note* the ease with which level time data can be extracted from these charts by simply entering basic work parameters.
- Sample *work orders were* tracked through the shop (other work going on concurrently was not tracked).

<u>Second Testing *Period*</u> - 30 Nov 1981 through 11 Dec 1981

- Purpose was to confirm the prediction *capability* of scheduling standards
- Seventeen work orders in sample, ranging in estimated size from 8 to 80 manhours.
- Level times obtained from classification scheme based on detailed MOST data.
- Sample work orders constituted ALL the work going on in the shop.

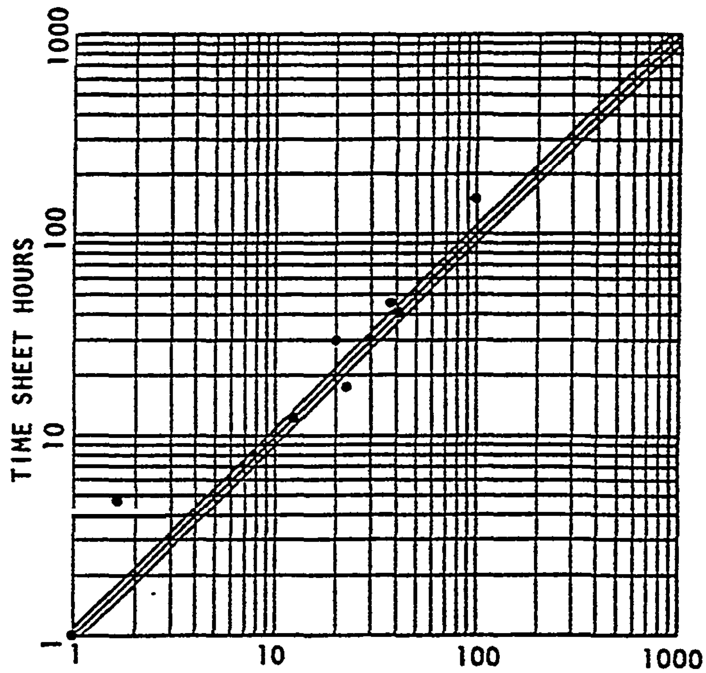
Third Testing Period - 22 Feb 1982 through 5 Mar 1982

- *Purpose was to* see *if* benefits *accrue when the shop is* carefully loaded using scheduling standard hours to predict actual work content.
- Twenty-eight work orders in sample, ranging in estimated size from 3 to 400 manhours.
- Level times obtained from classification scheme based on detailed MOST data.
- *Sample* work orders constituted ALL the work going on in the shop, although not all work orders in the sample were worked. *Work was* loaded to between 100 and 110% of the predicted workforce capability, maintaining a slight overload.

VI. ANALYSIS OF DATA

- The prediction capability of scheduling is is shown by scatter diagrams of TIME SHEET hours vs. scheduling standard hours. Level times were calculated as noted with each figure. Non-process factors determined from work sampling were slightly different for each testing period, reflecting the actual conditions at the *worksite.*

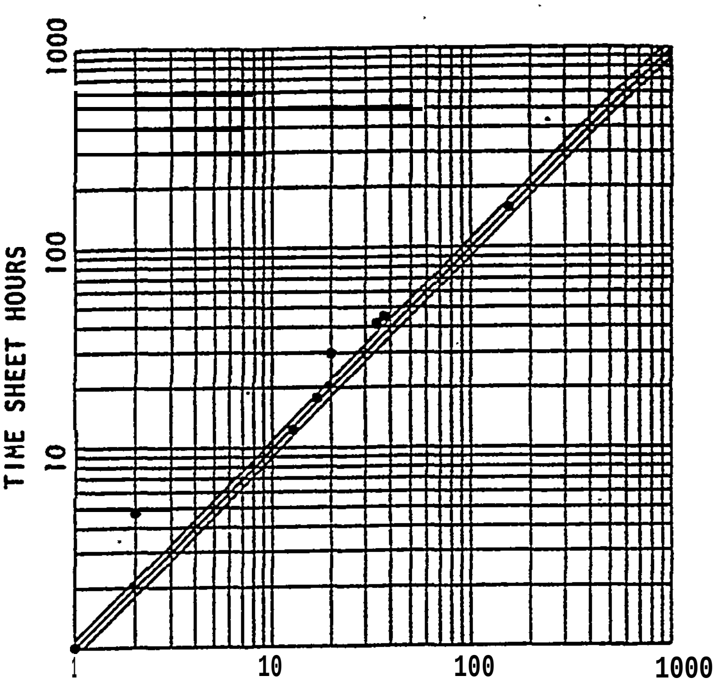
Figure 2 shows data from the first testing period using level times from detailed MOST. Note the small degree of scatter, and that the data points are close to the diagonal. This indicates that time sheet hours are quite close to the hours that the scheduling standards predict are necessary to accomplish those work orders.



FIRST TESTING PERIOD

Detailed Most

FIGURE 2

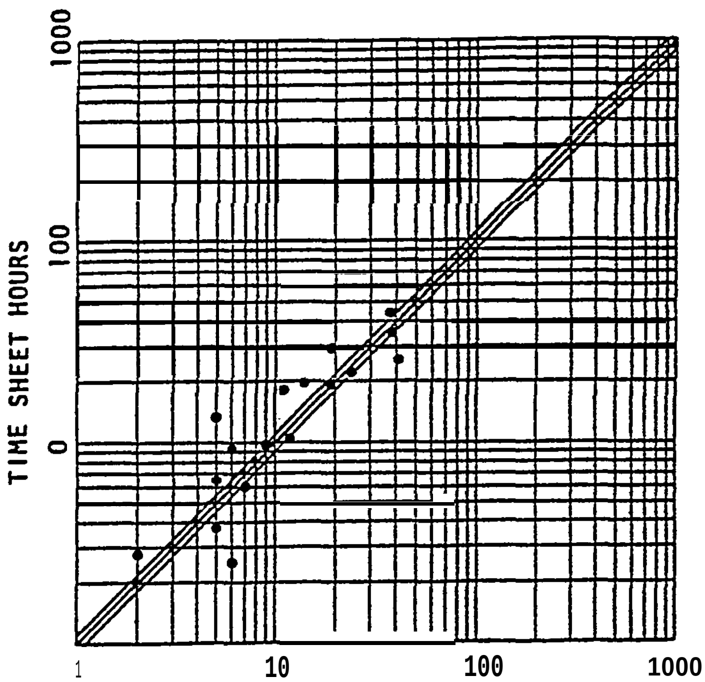


FIRST TESTING PERIOD

Classification Most

FIGURE 3

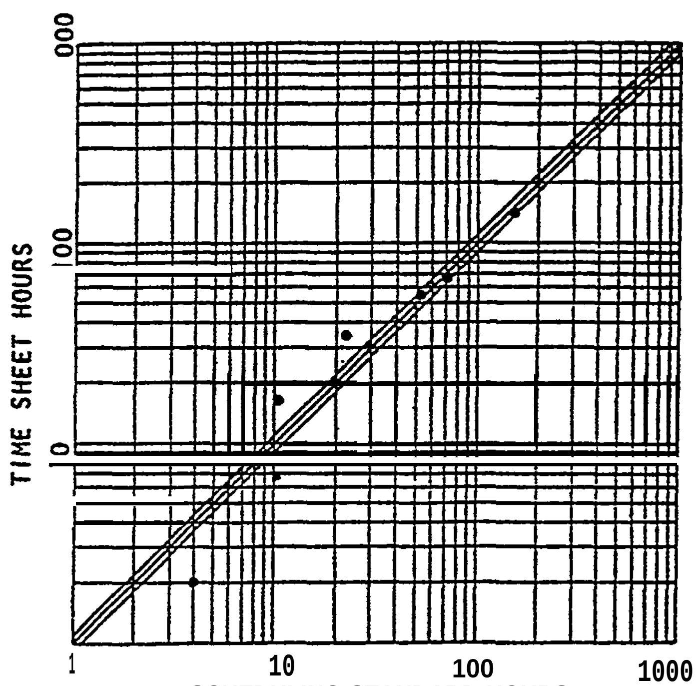
Figure 3 also shows data from the first testing period but using level times from the classification scheme based on detailed MOST data. Note the small differences between Figure 2 and Figure 3 from using the classification scheme. The data points are even closer to the diagonal, especially the large *work* order at about 160 hours. The classification scheme is much less time-consuming than direct use of detailed MOST data, and yet produces level times that are entirely satisfactory for use in developing scheduling standards.



SCHEDULING STANDARD HOURS
SECOND TESTING PERIOD
Classification Most
FIGURE 4

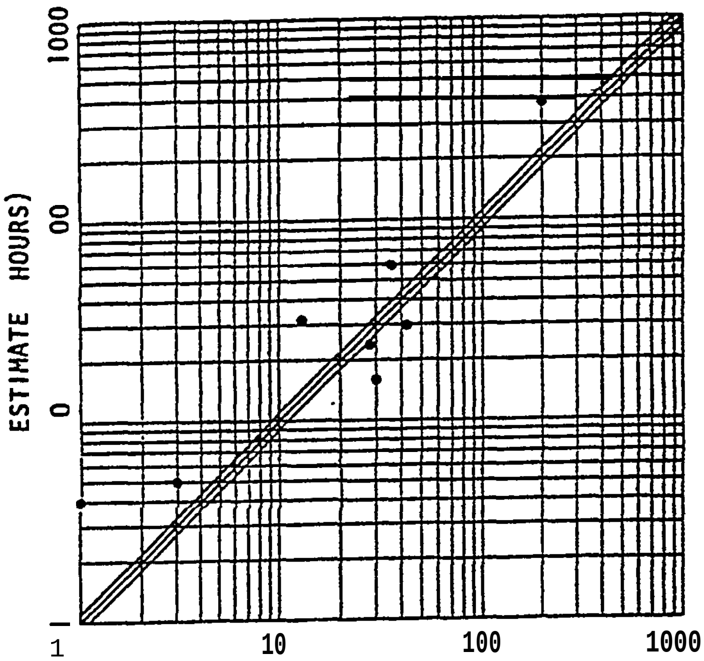
Figure 4 shows data from the second testing period using level times from the classification scheme based on detailed MOST data. Note that these work orders are fairly small in size the largest being only about 43 hours. Although not as close to the diagonal as desired, these data points are well distributed on either side of the diagonal, and indicate good prediction capability through use of scheduling standards

Figure 5 shows data from the third testing period using level times from the classification scheme based on detailed MOST data. Note that the larger work orders are ON the diagonal, and the others are close to it. Clearly, scheduling standards CAN predict real costs.



SCHEDULING STANDARD HOURS
THIRD TESTING PERIOD
Classification Most
FIGURE 5

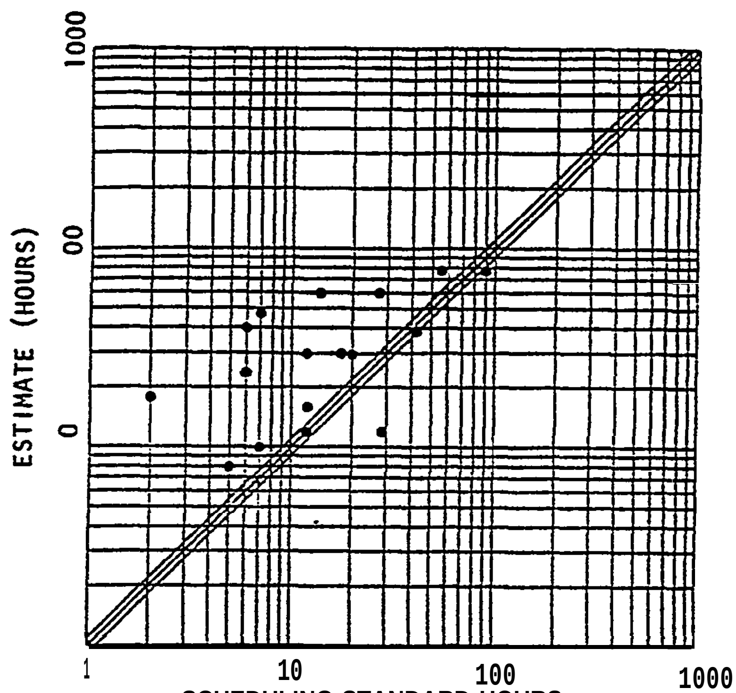
- **The relationship between previous ESTIMATES for work orders in each of the three samples, and the scheduling standard hours for those same work orders, is also shown by scatter diagrams. (Level times reflect the classification scheme based on detailed MOST data).**



SCHEDULING STANDARD HOURS
FIRST TESTING PERIOD
Classification MOST
FIGURE 6

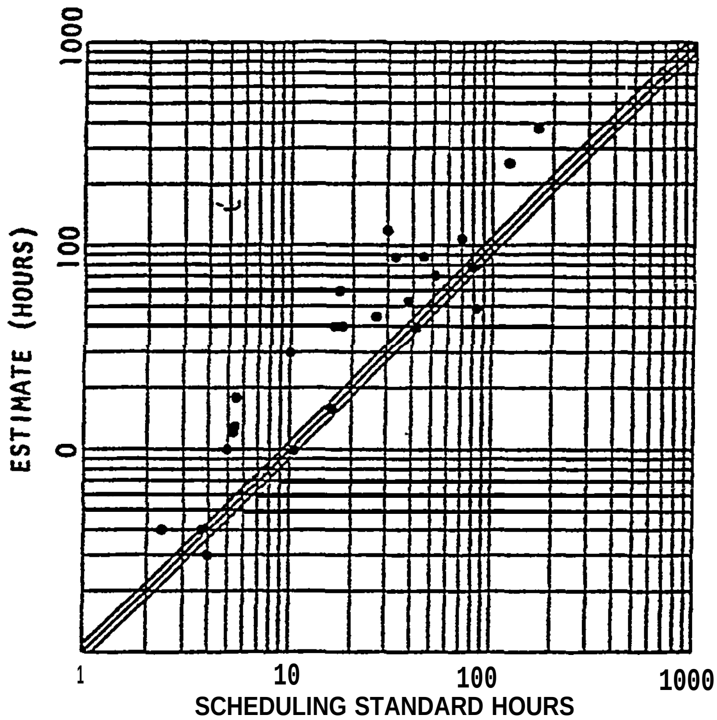
Figure 6 shows data for the work orders in the first sample. Although the sample size is small, scatter is not favorable. The data points are too far from the diagonal, and there is a hint that the estimated hours are generally higher than the scheduling standards say are needed to do the work.

Figure 7 shows data for the work orders in the second sample. Note that *most* of the data points are above the diagonal, indicating that estimated hours are generally higher than the scheduling standard hours. In addition to this clear bias toward heavy estimates, there is also wide scatter among the data points. *This* scatter reflects the unreliability of the estimates.



SCHEDULING STANDARD HOURS
SECOND TESTING PERIOD
Classification Most
FIGURE 7

Figure 8 shows data for the work orders in the third sample. Here the bias toward heavy estimates is quite pronounced. As mentioned earlier, it *is noxmal* for shipbuilding costs to simply *rise* until they match the budget (estimate) available (Reference a). Unrealistically high estimates, such as we have here, usually promote unnecessarily high return costs.



THIRD TESTING PERIOD

Classification *Most*

FIGURE 8

Special Note:

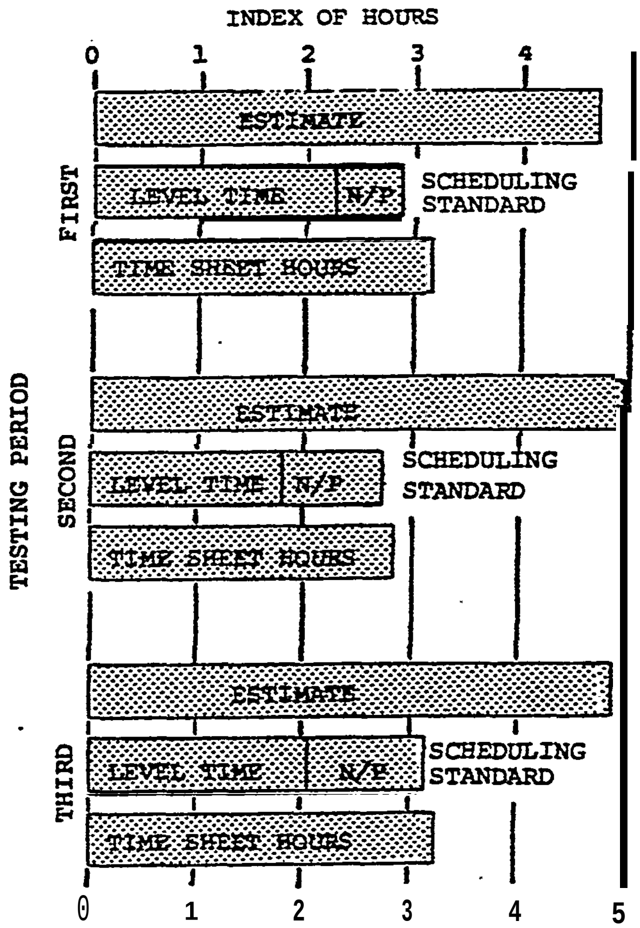
A legitimate first reaction to these data is to simply cut back on the estimates. However, the wide Scatter of these estimates is STILL a problem. Some estimates really need to be decreased while other estimates *need to be* increased. An across-the-board cut will do NOTHING to improve the credibility of the planner making these estimates. Production people will continue to view such blanket decreases in the same light, and will TRUST the reduced estimates even less than they did the inflated estimates. Scheduling standards are a tool with which the Planner can correct this situation. $cheduling standards CAN PREDICT the real work content of each work order, and thereby offer a solution to the credibility problem. Once production people gain confidence in the prediction capability of scheduling standards, a firm basis for planning and scheduling will have been created. Thereafter, excessive costs can be reduced as is seen below.

- The aggregated data for all work orders in each of the three samples is shown by the bar charts of Figure 9.

- In all three testing periods previous estimates are much larger than scheduling standard hours for the same work orders.

- Aqreement between time sheet hours and scheduling standard hours becomes progressively better during the three testing periods. (The non-process factor for the first sample was probably too small. This was perhaps due to unintentional favoring of sample work orders at the unknown expense of other untracked work going on concurrently, and the resulting data distortion. This Situation was remedied during the remaining testing periods by tracking ALL the work in the shop.)

During the third *testing* period, mechanic performance was at 96% of the scheduling standard hours. This level of performance is entirely acceptable for planning and scheduling purposes.



AGGREGATED DATA

FIGURE 9

- Additional analysis of data from this Project is provided in Reference (c), where statistical and other analyses are *used* to develop explanations for the differences between the level times and the actual times, which is that portion due to non-process factors. Two observations from Reference *(c)* are repeated here for reader convenience:

"One of the primary conclusions of the pilot study is that the actual production times are highly correlated with the level times, and that the relationship between them is relatively stable over time. This means that the level times do provide a very good basis for predicting the actual time required for a task.

> Another primary conclusion is that, with certain limitations, *even a very simple* method for converting the level times into scheduling standards can give good results. More complicated methods for obtaining scheduling standards from the level times give more accurate results, but the improvements are decreasing as the effort increases."

VII. CONCLUSIONS drawn from this Project are as follows:

Conclusion #1

scheduling standards accurately predict the manhours required to fabricate individual piping assemblies. This permits more accurate cost and schedule predictions.

Conclusion #2

Manhours used to fabricate pipe assemblies are reduced by about one-third through shop loading based *on* scheduling standards. This permits the fabrication of about 50% more pipe with the same number of fabricators.

Conclusion #3

Use of a classification scheme (in this case based on detailed MOST data) rather than direct use of detailed MOST data itself produces acceptable level times. This greatly reduces the effort required of shipyard personnel in developing shipbuilding standards.

VIII. SUMMARY

This Project established that:

(2) scheduling standards can be developed that realistically predict production *"will-cost" charges:*

(2) scheduling standards can facilitate shop loading;

(3) mechanics can perform to scheduling standard predictions;

(4) labor charges are the reduced to about two-thirds of previous expenditures for the same quantity of *work.*

Since manpower is the most expensive resource in shipbuilding, and is sometimes in limited supply, it is good business to produce more product for the same manpower expense. *Proper* application of scheduling standards can allow this to happen. In this particular instance, results show that about half-again as much work can be produced for the same (previous) cost. This increase (about 50%) can be sustained nas long as material supplies keep up, facilities are not overloaded, and the shop does not get so far ahead of the downstream shops that in-process inventories exceed, acceptable limits.

scheduling standards are a valuable tool *that is well* within reach today. This Project was successful, but is really only *a* beginning. The full potential of applying scheduling standards for planning end scheduling in shipbuilding has yet to be exploited.

IX. RECOMMENDATIONS

This Project was limited to one shop. The next logical step would be to apply the same technique in another shop, and then another, until all shops have been treated. Individual shop improvements will be substantial, as illustrated by the example of this Project.

when all shops have been improved individually, then careful sequencing and scheduling of production work across the whole shipyard should be carried out, using the prediction capability provided by scheduling standards. This will produce ANOTHER step change, this time in total-shipyard efficiency, as all contributing parts of the whole effort are meshed together effectively. The synergistic effect of applying engineered scheduling standards throughout a whole shipyard may well result in savings which are greater than the sum of the savings identified in the individual shops.

All of the above should be carried out in a small to medium size shipyard with a relatively short build cycle (of a few months) so that the whole problem can be surrounded in a reasonable length of time. Peterson Builders Inc. would be an ideal location. Once the techniques are developed and proven on a modest scale, they can be expanded and adjusted to suit the needs of the larger shipyards, where the same problems exist but with the added complications of a larger workforce, higher throughput, and longer build cycle (perhaps several years). Conducting this sort of exploratory development on a manageable scale will produce the best and most timely results.

REFERENCES

Reference (a) - A Manual on Planning and Production Control for shipyard Use, prepared by Corporate-Tech Planning, Inc., Portsmouth, NH 03801 for Bath Iron Works corporation, Bath, Maine 04530, September 1978.

Reference (b) - Labor Standard Classification System, a report prepared for Mr. Joseph R. Fortin, MarAd Program Manager SP-8 Program - Task EC-10 - Bath Iron Works, Bath, Maine, by H.B. Maynard and Company, Inc. Pittsburg, Pennsylvania 15221, January 1982.

APPENDIX A

TYPICAL CLASSIFICATION CHARTS

From

Labor Standard Classification System, a report prepared for Mr. Joseph R. Fortin, MarAd Program Manager SP-8 Program - Task Ec-10 - Bath Iron Works, Bath, Maine, by H.B. Maynard and Company, Inc., Pittsburgh Pennsylvania 15221, January 1982.

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APPENDIX A

CONRAC BENDER ESTIMATING STANDARDS - DECIMAL HOURS

INCLUDES: BENDING, CUTTING AND CLEANING

NUMBER OF BENDS	COPPER			COPPER NICKEL			[illegible]			STEEL & GALVANIZED		
	2"	3"	4"	2"	3"	4"	2"	3"	4"	2"	3"	4"
1	.18	.18	.18	.18	.18	.18	.18	.18	.18	.18	.18	.18
2	.32	.32	.32	.32	.32	.32	.32	.32	.50	.32	.32	.32
3	.50	.50	.50	.32	.32	.50	.50	.50	.72	.32	.50	.50
4	.50	.72	.72	.50	.50	.50	.72	.72	.98	.50	.50	.50
5	.72	.72	.72	.72	.72	.72	.72	.98	.98	.72	.72	.72
6	.72	.98	.98	.72	.72	.72	.98	1.3	1.3	.72	.72	.98
7	.98	.98	1.3	.98	.98	.98	1.3	1.3	1.6	.98	.98	.98
8	.98	1.3	1.3	.98	.98	.98	1.3	1.6	1.6	.98	.98	1.3
9	1.3	1.3	1.6	1.3	1.3	1.3	1.6	1.6	2.0	1.3	1.3	1.3
10	1.3	1.6	1.6	1.3	1.3	1.3	1.6	2.0	2.0	1.3	1.3	1.3

ADD FOR SET-UP: EACH MATERIAL CHANGE: .75
EACH DIAMETER CHANGE: 1.80

GREENLEE BENDERS
ESTIMATING STANDARDS - DECIMAL HOURS

Bending Only: Includes Set-Up

COPPER - COPPER NICKEL

NUMBER OF BENDS	1"	2"	3"	4"	5" *	6" *
1	.18	.18	.18	.18	.32	.32
2	.32	.32	.32	.32	.50	.50
3	.32	.32	.32	.32	.50	.72
4	.50	.50	.50	.50	.72	.72
5	.50	.50	.72	.72	.98	.98
6	.72	.72	.72	.72	.98	1.3
7	.72	.72	.72	.98	1.3	1.3
8	.72	.98	.98	.98	1.3	1.6
9	.98	.98	.98	.98	1.6	1.6
10	.98	.98	1.3	1.3	1.6	2.0

CRES, BLACK STEEL, & GALVANIZED

NUMBER OF BENDS	1"	2"	3"	4"	5" *	6" *	NUMBER OF BENDS
1	.18	.18	.18	.18	.32	.32	1
2	.32	.32	.32	.32	.50	.50	2
3	.32	.50	.50	.50	.72	.72	3
4	.50	.50	.50	.50	.98	.98	4
5	.72	.72	.72	.72	.98	.98	5
6	.72	.72	.72	.98	1.3	1.3	6
7	.72	.98	.98	.98	1.6	1.6	7
8	.98	.98	.98	1.3	1.6	1.6	8
9	.98	.98	1.3	1.3	2.0	2.0	9
10	1.3	1.3	1.3	1.3	2.0	2.0	10

* ADD FOR RESIN FILL: 4.0 HOURS EACH. 20 FT. LENGTH

APPENDIX B

EXCLUDING BENDING

Add for:

1 Hole Drilled: .15

1 End Threaded .09

Cres Pipe 2" Diam.

PIECES OF PIPE	NUMBER OF JOINTS BRAZED/FIT & TACK																
	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
1	.18	.32	.50														
2	.50				.72												
3	.72				.98			1.3									
4																	
5			1.3														
6					1.6			2.0									
7																	
8										2.4				2.9			
9																3.4	
10																	

LABOR STANDARD CLASSIFICATION SYSTEM

January, 1982

LABOR STANDARD CLASSIFICATION SYSTEM

a companion to the

SCHEDULING STANDARDS PILOT PROJECT

conducted at

PETERSON BUILDERS, INC.

STURGEON BAY., WISCONSIN

September, 1981 through April, 1982

Prepared by:

H. B. MAYNARD **and COMPANY, INC.**

PITTSBURGH, PENNSYLVANIA

for the

SHIP PRODUCIBILITY RESEARCH PROGRAM

BATH IRON **WORKS** CORPORATION

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TABLE OF CONTENTS

INTRODUCTION

Shipbuilding requires the extensive use of a multiplicity of crafts, as well as manufacturing and construction operations? often for the construction of one-of-a-kind products. It is most important that a shipbuilder have the capability for rapidly estimating the labor content of a vessel accurately, if he is to submit a bid that is correct, and with which he can comply. Compliance with a bid depends on his ability to correctly apply manpower to the various craft work involved, and on his ability to effectively schedule those crafts on a daily basis.

Labor standards developed by the use of Engineered Time Standards Systems are quite detailed, and require a detailed knowledge of the engineering specifications of the work. For shipyard use, there is often a lack Of detail either available or early enough to be used for the task of developing standards for the immediate design being considered. The use of MOST® Systems for developing standards is a distinct advantage? allowing the maximum development of standards with a minimum investment of time. The use of statistical techniques to accommodate the variations in work methods and the lack of repetitive work common to long-cycle job shop type operations further commends the use of MOST for shipyard applications. However, the application of the standards that are developed may be as time-consuming, and require as much detailed information, with MOST as with any other standard development system.

The concept of Labor Standard Classification is an adaptation of the standard data approach, and has been developed to permit the rapid application of valid labor standards for estimating and for manpower scheduling. The work detailed in this report is only the first step toward the goal, and is the result of a need for providing for the rapid development of accurate labor standards for use in a pilot shop scheduling program. That pilot program covers the conversion of Base Leveled Standard Times to Application (Scheduling) Standards for use in shop loading and scheduling.

LABOR STANDARD CLASSIFICATION FOR PIPE SHOP FABRICATION

The classification system developed for the Pipe Fabrication Shop is based on actual organization of work in the shop. Three basic work centers were identified:

Bending - Conrac
Bending - Greenlee
Pipefitting (mechanic)

It should be noted that the work for the Conrac Bender is set up on separate work orders? while the work for the Greenlee Benders is made up of work not covered by Conrac tooling, and performed generally as encountered on pipe details.

Generally, the mechanics are assigned an entire work order, unless it is a large one requiring the use of two or more men to complete it in a timely manner.

Three chart sets are used for selecting the classification standard: one set each for the benders, arid one set for all other work. Two work sheets are used to accumulate the information necessary for the use of the charts. Filling out the work sheets is the first step.

Two documents (prints) provide directions to the shop: the Supplementary Instruction Sheet (SIS) gives instructions for bending; the Pipe Detail Sketch provides the information for the mechanic's fabrication and assembly (see Appendix 1 for examples).

1. Bending Work Sheet - *Conrac OnlY* (see Figure I)

The first step **in** use of the work sheet is to record the work order number at the head of the sheet. You are then ready *to* record data for each Supplemental Information Sheet (SIS) that is included *in the* work order. In order to minimize the set-up time, all the SIS sheets should be arranged first by diameter of pipe, and then by material within each diameter group. From each SIS sheet you then record on the work sheet: the SIS number, the material the pipe diameter, and the actual number of bends that are to be made. The column headed "Stand. Time" is left blank at this point. When all of the SIS sheets have been recorded, count the number of times a different material was listed, and record that number in the blank space after "Set-up - Material" in the bottom right corner of the form. Then count the number of different diameters shown, and record that number **in the** blank after "Set-up - Diam."

The next step is the use of the Standard Classification Chart (see Appendix A) to select the *time* values to be assigned. The time values represent

Figure I

BENDING WORK ORDER NO. ______

ESTIMATING WORK SHEET
(CONRAC BENDER ONLY)

S.I.S. NO.	MAT'L.	DIAM.	NUMBER OF BENDS	STAND. TIME	S.I.S. NO.	MAT'L.	DIAM.	NUMBER OF BENDS	STAND. TIME

COL. TOTAL	
PREV. TOTAL	
TOTAL FORWARD	

COL. TOTAL	
PREV. TOTAL	
TOTAL FORWARD	
SET-UP - MATERIAL ______ X .75 =	
SET-UP - DIAM. ______ X 1.18 =	
TOTAL	

the classification standard which is leveled at 15% PF&D (Personal, Fatigue and Delay). To select the proper time value, reference is made to the material, the pipe diameter, and the number of bends required for each SIS sheet. The indicated time value is then inserted in the appropriate column on the Work Sheet (Figure I). The individual SIS values are then totaled for the work order, the set-up times are calculated, and the total is calculated.

That total time is then modified in accord with the procedure given in the pilot program report to give the total man-hours for the work order.

II. Pipe Detail Work Sheet - Including Greenlee Bending (see Figure II)

The first step in the use of the Pipe Detail Work Sheet is to record the work order number and the drawing number. You are then ready to analyze the detail sketches and record the pertinent information. In order to simplify later reference to the classification charts, it is desirable to arrange the pipe detail sketches first by material, and then by ascending order of pipe diameter within each material group.

FIGURE II

PIPE DETAIL WORK ORDER NO. ________

DRAWING NO.: ____________________________

ESTIMATING WORK SHEET

SPEC.			COUNT						STANDARD TIME					
													TOTAL	
DET'L. NO.	MAT'L.	DIAM	PCS.	MADE UP JOINTS	HOLES DRILL	END THREAD		GREEN BENDS	FAS	DRILL	THD		MECH.	BENDS

PAGE TOTAL		
PREV. TOTAL		
TOTAL FORWARD		

The next step is to identify and record the following information for each pipe detail sketch:

A. The sketch number (including revision letter).

B. The material (if more than one material is used, a separate line should be used for each material).

C. The pipe diameter (if more than one diameter is required, a separate line should be used for each diameter).

D. The number of pieces of pipe {for each material and diameter, if necessary).

E. The number of made-up joints (joints brazed or fit and tack - including brazolets or weldolets, where used).

F. The number of holes to be drilled for brazolets or weldolets.

G. The number of pipe ends that are threaded.

E. Any other odd operation such as burning a hole or pipe end with the portable plasma unit.

1. The number of bends required for the Greenlee Bender. These will be all bends on pipe less than 2" diameter, or greater than 4" diameter. Further, any bend with a radius smaller or larger than two pipe diameters, or bends on 2" through 4" pipe where no SIS sheet has been referred to in the notes on the sketch.

It is most important that the analyst be aware of shop practice. For example, notes on the sketches will often refer to certain fittings that are "left loose." In addition, it is a shop practice that all flanges are left loose.

The next step is to use the classification charts to determine the standard times for each pipe detail. The chart for Greenlee Benders is found in Appendix B, and the chart sets for Fabrication are found in Appendix C.

The determination of the time for the Greenlee Benders is done in the same manner as for the Conrac, with two exceptions. First, there is no separate set-up time and, second, when 5" or 6" pipe is involved, time must be added for filling and removing resin from the interior of the pipe. The base time is indicated on the bottom of the classification chart (see Appendix B) and the proportionate amount of time should be used for the approximate length of the pipe to be bent.

The total of Greenlee bending time is calculated for the entire work order as a separate value.

Reference is made to the Fabrication Classification Charts (see Appendix C) for selection of classification standards. These charts are in sets according to the material and, within each set, these is a chart for each one inch diameter increment. The charts are cross charts, that is, there are two determinants for selecting a time. Along the left side of the chart you will find the number of pieces of pipe, and along the top you will find the number of made-up joints. The value is given at the intersection of the two cohmns. Separate values are listed at the top of each chart for hole-drilling time and for pipe-end threading time.

Once the times are recorded in the appropriate columns on the right side of the work sheet (Figure II) they are summed to give a total fabrication time for each pipe detail. The "Total" column is then summed to provide the total base time (leveled with 15% PF&D) for the work order. Again, this is the time used in accord with the procedures reported in the pilot program report.

When such values as plasma burning are required, the Industrial Engineering Department will provide the necessary standard values to be used.

CIASSIFICATION SYSTEM DEVELOPMENT

In this section we detail the steps used to develop the classification system.

I. Concept and Development Guide

The classification system has been developed to provide *a relatively* simple method of determining basic standard hours *(at 100%* **performance** and including asigned PF&D) with a minimum of analyst or planner hours required. There is always *a* temptation to try to preestablish the end result and work backward, but **it is** most important to use a see **of** guiding parameters only, and to begin with the detailed data, working forward to **a** final for, mate

The basic parameters **chosen** for the Pipe Shop were:

A. Use whole inch pipe sizes *to* reduce the **number** of *references* from fifteen to seven sizes.

B. Use a time spread approach to establish time families (with a 5% accuracy) to compensate for the compression of pipe sizes and the addition of that variable to the already-existing variables accommodated by MOST Systems.

The time spread selected for shipyard application is shown in Appendix D. It was developed using the integer square method.

Guided by the parameters, the following analytical procedure was used for the development of the system:

A. Define the work functions performed, the operations sequences, and the work centers in use. within the shop.

B. Determine the time standards applicable to each identified work activity.

C. Analyze the work orders, and the engineering drawings to define the typical operations performed at each work center, as well as the identifiable relationships between each work activity in the work center.

D. Determine the minimum number of physical characteristics encountered in each drawing that will define the work activities used.

E. Construct a classification system.

F. Test the system by comparing standard times determined from detailed standards with those determined from the classification system.

G. Revise the system, as necessary, until there is a consistent relationship between the values as determined in Seep F.

II. Pipe Shop - Work Centers, Work Activities and Sequences

In Pipe Shop 70 the following operations were defined:

A. Conrac Bender:

1. Review SIS sheets, and redimension to Provide about 1" additional length per piece after cut-off.

2. Read instructions and set up bender.

3. Get pipe and anneal, as required.

4. Load bender.

5. Bend pipe.

6. Unload bender and set bent pipe aside.

7. Take pipe to cut-off saw.

8. Cut off bent pipe sections, mark and set aside.

9. Take pipe to washer table - lead table.

10. Wash lubricant out of pipe.

11. Set pipe on appropriate pallets for storage.

B. Greenlee Bender:

1. Check instructions (fill large 5" and 6" pipe with resin).

2. Set up bender.

3. Bend pipe.

4. Remove resin from large pipe.

5. Set pipe aside for return to mechanic.

c. Mechanic:

1. Check instructions.

2. Get pipe, cut to length and mark.

3. Take cut pipe to bench.

   a. Take pipe requiring bends to Greenlee.

   b. Get pipe from Greenlee Bender and take to bench.

4. End prep pipe.

5. Get fittings.

6. Drill or burn pipe and fittings, as required.

7. Fit and braze or fit and tack fittings, as required.

8. Inspect completed pipe details.

9. Cap or tape all openings.

10. Place pipe detail on pallet.

III. Standard Hour Determination

The original Pipe Shop Work Management Manual (WMM) has been prepared for work done in shop 5. Subsequently, the fabrication work had been transferred to Shop 70, and the Conrac Bender had been installed. Most of the standards for the Conrac Bender had been developed and added to the Manual. However, it was now necessary to review the existing standards and ensure that they were correct for the work being done in Shop 70, and to prepare whatever additional standards were needed. It was also found that some standards had been combined for original application work. Some of those combinations were not compatible with the procedures being followed in Shop 70, and the necessary separation was made.

It was most important to be sure that standards were established for each individual work activity, since future combinations might have to be revised.

Appendix E is a summary table of individual standards taken from the WMM and from the additional standards developed for Shop 70.

IV. Work Activity Analysis and Decisions

In order to determine the type of work activity actually being carried out, a large number of pipe detail sketches and SIS sheets were selected at random, and analyzed in detail for work requirements. The analysis took careful account of both engineering instructions and shop practice. Different colors of Highliner Pens were most helpful in highlighting the work activities required on the sketches.

The following points were determined by the analytical activity:

A. Due to the practice of leaving about 1" excess when cutting Conrac bent pipe, the, mechanic has to final-cut each piece when fitting pipe and fittings or when making end preps.

B. A small percentage of-pipe pieces have an end prep specified on one end only.

C. The existing supply of sockolets and weldolets is not predrilled and must be drilled for pipe insertion, as well as having to drill the access hole in the pipe. Brazolets, however, are predrilled.

D. Engineering notes about fittings must be carefully checked when there are two or more of that fitting on the pipe detail. If note numbers are on the sketch by the fitting designation, only those fittings are to be left loose. If no note numbers are in the sketch, the note will be considered to apply to all of that fitting.

E. Shop 70 does not make up pipe hangers or any similar components.

F. Fabricated bell mouths are made up in Shop 70.

G. Except as noted, all ferrous pipe through 2" diamater is socket-welded, while all over 2" diameter is butt-welded. The primary exceptions are found when reducing couplings or tees are used. In those instances when the larger end is over 2", all connections are butt-welds. The deviations affect the pipe end prep.

H. Tooling for bending 1", 1-1/4" and 1-1/2" diameter pipe on the Conrac Bender is on order.

I. Molded plastic caps are available for protecting the ends of all pipe through 5" diameter.

All openings on fittings, brazolets or socko-lets and on pipe over 5" diameter, are taped.

J. The number of ends or openings to be protected (cap or tape) is a function of the number of joints made up and of the type of fitting used.

K. The use of weldolets, brazolets and of thread-ed pipe ends is specific to certain pipe de-tails; it is not an overall application.

L. On the SIS sheets? there are an avesage 0.7 cuts per bend.

M. Over 50% of the bends are 90°.

N. There are no standards for aluminum or brass pipe.

O. Heavy wall or hydraulic piping is not handled in shop 70.

P. work orders containing both hydraulic and standard pipe are proportionately split be-tween the Hydraulic Shop and Shop 70.

Q. Work performed in the Machine Shop (e.g., removing internal threads from one end of a threaded coupling) is normally not charged to the Shop 70 work order. It also appears that final welding of fittings is not charged to the Shop 70 work order.

Based on those observations, and the frequency of occurrence of such events as "one-end pipe end. prep," a number of decisions were made to lead toward the determination of key factors that define the labor content of pipe detail.

The observations were initially grouped into three classifications:

A. Those operations that always occurred at a definable frequency.

B. Those operations that always occurred, but at a variable frequency.

C. Those operations that occurred occasionally.

The groupings established the logical selection of readily definable elements that could be used for determining the labor standards for pipe details, as follows:

A. Conrac Bender work.

1. Operations always occurring at a definable frequency:

   a. The number of bends on each SIS.

   b. There are 0.7 cuts made for each bend.

   c. The number of cut pieces of pipe that can be washed at a time is a function of pipe diameter (a definable number of pieces of pipe of a given size can be placed on the cleaning table at one time).

2. Operations always occurring at a variable frequency:

   a. Set-up for material changes.

   b. Set-up for diameter changes.

   c. Operations occurring occasionally - NONE.

B. Greenlee Bender work.

1. Operations always occurring at a definable frequecy:

   a. The number of bends required.

   b. The degree of bend.

2. Operations always occurring at a variable frequency:

   a. The cut-off of a pipe piece - before or after bending.

3. Operations occurring occasionally - NONE.

C. Mechanics.

1. Operations always occurring at a definable frequency:

   a. Each straight piece of pipe has one cut.

   b. Each pipe opening is capped or taped.

   c. Each piece of pipe is inspected.

2. Operations always occurring at a variable frequency:

   a. Each bent piece of pipe may have one or two additional cuts.

   b. The type of end prep is defined by the size and material of the pipe, except where no end prep is specified or where a reducing fitting is used across a size boundary.

3. Operations occurring occasionally:

   a. Pipe ends threaded.

   b. Pipe drilled for brazolet/weldolet addition.

   c. Weldolet drilling required.

Evaluation of the work activity analysis led to the following preliminary decisions for classification purposes.

A. Conrac Bender.

1. Operations such as cut-off and clean can be directly related to the number of bends required on each SIS.

2. Set-up times must be determined separately for each work order.

B. Greenlee **Benders.**

1. Due to the work practice followed for Greenlee Bender **work, a** set-up could be allowed for each bend.

2. NO cutoff would be included in the bend time, and that time would be included with the mechanic-s work.

3. A single bend time would be selected, regardless of the actual degree of bend required.

C. Mechanics.

1. Each piece of pipe would require one cut-off, **two** end preps, and **one** inspection.

2. End prep values would be allowed strictly in accord with the basic material and diameter of the pipe.

3. Fitting makeup (braze or fit and tack) will be defined for actual joints required.

4. Caps or taping for ends can be defined on an average basis for varying configurations of pipe detail fabrication. Further, the average number required can be related to the relationship between pieces of pipe and made-up joints on each pipe detail.

5. Time for pipe threading and for drilling will be added on a per-occurrence basis.

6. Set-up values will be distributed for average frequencies.

Appendix F is a summary table of time standards (including a 15% PF&D) developed in accord with the preliminary decisions outlined above.

V. Chart Development

Based on the values given in Appendix F, it was a simple matter to construct basic tables for both the Conrac and Greenlee Bending operations, as shown in Appendices A and B.

Mechanic's work, however, requires the basic determination of two factors: the number of pieces ef pipe, and the number of made-up joints - for each pipe detail. It became necessary to construct a cross-chart, giving proper values for various combinations of pipe quantity and made-up joints. For each combination, an average number of cap/tape requirements for openings could also be determined. Appendix G shows a sample of the calculation process for determining the final values that were inserted in the cross-charts shown in Appendix C.

You will note that all values used in the development of the cross-charts are shown to two decimal places. In each case, the basis was the four-place number shown in Appendix F, and rounding off was done after multiplying the four-place value by the appropriate frequency.

You will also note that the calculation sheet shown in Appendix G assigns a Class Code to each time value. The time value assigned in the classification charts is the appropriate time value for the Class Code as shown on the table in Appendix D.

TESTING THE CLASSIFICAT10N CHARTS

The validity of the decisions and combinations used to **construct the classification** charts was tested by applying both basic standards and values from the classification charts to a number of work orders. ***The*** result for one such test is shown in Appendix H. As can be seen, there is a relatively consistent deviation of + 8%.

For the purposes of establishing **a** base for gross shop loading, the size of the deviation is not significant, as long as there is a consistency to that deviation. **It was** further required to use the chart **values as the** basis for determining the performance and delay (non-process) ***factors that would modify the base*** times and provide a realistic application (scheduling) standard.

FUTURE SYSTEM MODIFICATION REQUIREMENTS

There are several events that will signal the need to modify or recalculate the existing charts:

1. The Conrac Bending Chart will have to be expanded to include a 1" size at such time as the new tooling is put into production.

II. Any change in shop procedure will require a modification of the assigned values and, perhaps, of the basis for the chart. For example:

A. If molded caps were supplied for all pipe ends and for fittings the cap/tape value would have. to be reviewed and probably revised.

B. If some welding operations were added to the shop 70 work activities, the appropriate make-up joint values would have to be suitably increased.

III. If Greenlee bending requirements reach a significant quantity to require an accumulation of bends and a better work scheduler set-up values may have to be separated and assigned on a planned basis.

It is also true that if there is a high volume of a specific size of pipe, particularly at the intermediate 1/2″ sizes, it may be desirable to develop a special chart for that size of pipe.

CONCLUSION

The classification chart system for determining basic labor standards for pipe detail fabrication work provides a simplified application method that can be used by a planner on a daily basis. It represents a pragmatic use of the highly-detailed labor standards that provide the valid basis for the classification system.

There are two future advances anticipated for the system:

I. The chart concept can be applied to a computer program, permitting the use of a computer terminal to provide the necessary calculation instead of using the manual method described in this report.

II. When sufficient basic labor standards are available, the system can be expanded to cover all pipe Shop activity from initial fabrication through final outfitting on the ship. At that time, it will be possible to develop basic system standards (i.e., lube-oil system, waste-water system, etc.) that can be effectively used as benchmarks for estimating the labor content of new ships (gross, by craft, and by yard location) for bidding purposes.

Finally, it should be understood that modifications of the system may be required for use at various levels of management information and/or control systems. For example, standards from the classification charts should never be used as the basis for an incentive program.

The classification system for determining labor standards is a tool for management. Like any good tool, it must be made or constructed for a specific use or application. When used for its original purpose, it will do an excellent job.

We are looking forward to further exploration of the classification system concept as additional applications are made of the labor standards being developed under the Marad Program

January, 1982

H. B. Maynard and Company, Inc.
Pittsburgh, Pennsylvania

APPENDICES

APPENDIX A

APPENDIX A

CONRAC BENDER ESTIMATING STANDARDS - DECIMAL HOURS

INCLUDES: BENDING, CUTTING AND CLEANING

NUMBER OF BENDS	COPPER			COPPER NICKEL			CRES			STEEL & GALVANIZED		
	2"	3"	4"	2"	3"	4"	2"	3"	4"	2"	3"	4"
1		.18			.18			.18			.18	
		.32		.32			.32		.50	.32		
3	.50						.50		.72		.50	
4						.50	.72		.98			
5		.72			.72						.72	
6							.98					
7		.98			.98			1.3			.98	
8												
9		1.3			1.3			1.6			1.3	
10			1.6						2.0			

ADD FOR SET-UP: EACH MATERIAL CHANGE: .75
EACH DIAMETER CHANGE: 1.80

APPENDIX B

GREENLEE BENDERS
ESTIMATING STANDARDS - DECIMAL HOURS

Bending Only: Includes Set-Up

COPPER - COPPER NICKEL						
NUMBER OF BENDS	1"	2"	3"	4"	5" *	6" *
1	.18	.18	.18	.18	.32	.32
2	.32	.32	.32	.32	.50	.50
3	.32	.32	.32	.32	.50	.72
4	.50	.50	.50	.50	.72	.72
5	.50	.72	.72	.72	.98	.98
6	.72	.72	.72	.72	.98	1.3
7	.72	.72	.72	.98	1.3	1.3
8	.72	.98	.98	.98	1.3	1.6
9	.98	.98	.98	.98	1.6	1.6
10	.98	.98	1.3	1.3	1.6	2.0

NUMBER OF BENDS	CRES, BLACK STEEL, & GALVANIZED						NUMBER OF BENDS
	1"	2"	3"	4"	5" *	6" *	
1	.18	.18	.18	.18	.32	.32	1
2	.32	.32	.32	.32	.50	.50	2
3	.32	.50	.50	.50	.72	.72	3
4	.50	.50	.50	.50	.98	.98	4
5	.72	.72	.72	.72	.98	.98	5
6	.72	.72	.72	.72	1.3	1.3	6
7	.72	.98	.98	.98	1.6	1.6	7
8	.98	.98	.98	1.3	1.6	1.6	8
9	.98	.98	1.3	1.3	2.0	2.0	9
10	1.3	1.3	1.3	1.3	2.0	2.0	10

* ADD FOR RESIN FILL: 4.0 HOURS EACH 20 FT. LENGTH

APPENDIX B

APPENDIX C.

FABRICATION ESTIMATING STANDARDS IN DECIMAL HOURS
EXCLUDING BENDING

Add for:
1 Hole Drilled: .27
1 End Threaded: -

Copper-Copper Nickel Pipe

1" Diam.

PIECES OF PIPE	NUMBER OF JOINTS BRAZED/FIT & TACK																
	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
1	.18																
2		.32		.50	.72												
3		.50															
4		.72			.98												
5							1.3										
6										1.6							
7												2.0					
8														2.4			
9																2.9	
10																	

APPENDIX C

FABRICATION ESTIMATING STANDARDS IN DECIMAL HOURS
EXCLUDING BENDING

Add for:

1 Hole Drilled: .27

1 End Threaded --

Copper - Copper Nickel **Pipe** 2" **Diam.**

PIECES OF PIPE	NUMBER OF JOINTS BRAZED/FIT & TACK 0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
1	.18	.32															
2	.32		.50		.72	.98											
3	.50																
4		.72		.98		1.3											
5							1.6										
6									2.0			2.4					
7																	
8														2.9			
9																3.4	
10																	3.9

FABRICATION ESTIMATING STANDARDS IN DECIMAL HOURS
EXCLUDING BENDING

Add for:

1 Hole Drilled: .27

1 End Threaded --

Copper - Copper Nickel **Pipe**

3" **Diam.**

PIECES OF PIPE	NUMBER OF JOINTS BRAZED/FIT & TACK																
	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
1	.18	.32	.50		.98												
2	.32	.50		.72													
3	.50	.72															
4	.72		.98		1.3												
5						1.6											
6								2.0									
7									2.4								
8											2.9						
9													3.4				
10															3.9		4.5

FABRICATION ESTIMATING STANDARDS IN DECIMAL HOURS
EXCLUDING BENDING

Add for:

1 Hole Drilled: .27

1 End Threaded —

Copper - Copper Nickel Pipe

4" Diam.

PIECES OF PIPE	NUMBER OF JOINTS BRAZED/FIT & TACK: 0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
1	.18	.50	.72	.98													
2	.32																
3	.50	.72	.98														
4	.72		1.3														
5	.98				1.6		2.0										
6								2.4									
7	1.3								2.9								
8											3.4						
9	1.6												3.9			4.5	
10																	5.1

FABRICATION ESTIMATING STANDARDS IN DECIMAL HOURS EXCLUDING BENDING

Add for:
1 Hole Drilled: .27
1 End Threaded --

Copper - Copper Nickel Pipe

5" Diam.

PIECES OF PIPE	NUMBER OF JOINTS BRAZED/FIT & TACK 0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
1	.18	.50	.72	.98	1.3	1.6											
2	.32																
3	.50	.72	.98	1.3													
4	.72	.98	1.3					2.4									
5	.98	1.3		1.6		2.0											
6								2.9									
7	1.3					2.4				3.4		3.9					
8			2.0											4.5		5.1	
9	1.6																5.8
10		2.0															

FABRICATION ESTIMATING STANDARDS IN DECIMAL HOURS
EXCLUDING BENDING

Add for:

1 Hole Drilled: .27

1 End Threaded --

Copper - Copper Nickel Pipe

6" Diam.

PIECES OF PIPE	NUMBER OF JOINTS BRAZED/FIT & TACK 0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
1	.18	.50	.72	1.3													
2	.32	.72	.98			2.0											
3	.50				1.6												
4	.72	.98	1.3				2.4										
5	.98	1.3			2.0												
6	1.3		1.6				2.9		3.4								
7					2.4					3.9							
8	1.6		2.0								4.5						
9													5.1				
10	2.0		2.4											5.8			6.5

FABRICATION ESTIMATING STANDARDS IN DECIMAL HOURS
EXCLUDING BENDING

Add for:

1 Hole Drilled: .27

1 End Threaded —

Copper - Copper Nickel Pipe

8 " Diam.

PIECES OF PIPE	NUMBER OF JOINTS BRAZED/FIT & TACK 0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
1	.18	.50	.98	1.3													
2	.50	.72															
3		.98	1.3	1.6	2.0	2.4											
4	.72						2.9	3.4									
5	.98	1.3	1.6	2.0	2.4												
6	1.3	1.6	2.0		2.9												
7				2.4				3.9									
8	1.6	2.0				3.4			4.5								
9	2.0	2.4		2.9						5.1		5.8		6.5		7.2	
10																	8.0

C-7

FABRICATION ESTIMATING STANDARDS IN DECIMAL HOURS
EXCLUDING BENDING

Add for:

1 Hole Drilled: .15

1 End Threaded .09

Cres Pipe

1" Diam.

PIECES OF PIPE	NUMBER OF JOINTS BRAZED/FIT & TACK																
	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
1	.18	.32		.50													
2		.50			.72												
3		.72			.98												
4							1.3										
5										1.6							
6												2.0					
7													2.4				
8															2.9		
9																	
10																3.4	

FABRICATION ESTIMATING STANDARDS IN DECIMAL HOURS
EXCLUDING BENDING

Add for:

1 Hole Drilled: .15   Cres **Pipe**   2" **Diam.**

1 End Threaded .09

PIECES OF PIPE	NUMBER OF JOINTS BRAZED/FIT & TACK																
	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
1	.18	.32	.50														
2	.50				.72												
3	.72				.98			1.3									
4																	
5			1.3														
6					1.6			2.0									
7																	
8									2.4								
9														2.9		3.4	
10																	

FABRICATION ESTIMATING STANDARDS IN DECIMAL HOURS
EXCLUDING BENDING

Add for:

1 Hole Drilled: .15

1 End Threaded .09

Cres Pipe

3" Diam.

PIECES OF PIPE	NUMBER OF JOINTS BRAZED/FIT & TACK 0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
1	.32		.50														
2	.50				.72	.98											
3	.72			.98		1.3											
4																	
5	1.3					1.6											
6								2.0									
7										2.4							
8													2.9				
9															3.4		
10																3.9	

C-10

FABRICATION ESTIMATING STANDARDS IN DECIMAL HOURS
EXCLUDING BENDING

Add for:

1 Hole Drilled: .15 — Cres Pipe — 4" Diam.

1 End Threaded: —

PIECES OF PIPE	NUMBER OF JOINTS BRAZED/FIT & TACK																
	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
1	.32		.50														
2	.50		.72		.98												
3			.98				1.3										
4		1.3			1.6												
5							2.0										
6								2.4									
7											2.9						
8													3.4				
9															3.9		
10																	4.5

FABRICATION ESTIMATING STANDARDS IN DECIMAL HOURS
EXCLUDING BENDING

Add for:

1 Hole Drilled: .15 Cres **Pipe** 5" **Diam.**

1 End Threaded ____

PIECES OF PIPE	NUMBER OF JOINTS BRAZED/FIT & TACK																
	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
1	.50		.72		.98												
2	.98			1.3				1.6									
3	1.3		1.6				2.0										
4	1.6	2.0					2.4										
5	2.0	2.4				2.9											
6							3.4										
7								3.9									
8										4.5							
9												5.1					
10														5.8			

FABRICATION ESTIMATING STANDARDS IN DECIMAL HOURS
EXCLUDING BENDING

Add for:

1 Hole Drilled: .15

1 End Threaded ______

Cres Pipe

6" Diam.

PIECES OF PIPE	NUMBER OF JOINTS BRAZED/FIT & TACK																
	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
1	.50	.72		.98													
2	.98		1.3			1.6											
3	1.6				2.0				2.4								
4	2.0			2.4				2.9									
5	2.4	2.9						3.4									
6	2.9	3.4						3.9									
7	3.4																
8			4.5														
9				5.1													
10					5.8								6.5				

C-13

FABRICATION ESTIMATING STANDARDS IN DECIMAL HOURS
EXCLUDING BENDING

Add for:

1 Hole Drilled: .15 Cres **Pipe** 8" **Diam.**

1 End Threaded ________

<table>
<tr><th rowspan="2">PIECES OF PIPE</th><th colspan="17">NUMBER OF JOINTS BRAZED/FIT & TACK</th></tr>
<tr><th>0</th><th>1</th><th>2</th><th>3</th><th>4</th><th>5</th><th>6</th><th>7</th><th>8</th><th>9</th><th>10</th><th>11</th><th>12</th><th>13</th><th>14</th><th>15</th><th>16</th></tr>
<tr><td>1</td><td colspan="3">.72</td><td colspan="2">.98</td><td>1.3</td><td colspan="11"></td></tr>
<tr><td>2</td><td colspan="3">1.3</td><td colspan="3">1.6</td><td colspan="2">2.0</td><td colspan="9"></td></tr>
<tr><td>3</td><td colspan="5">2.0</td><td colspan="4">2.4</td><td>2.9</td><td colspan="7"></td></tr>
<tr><td>4</td><td colspan="2">2.4</td><td colspan="6">2.9</td><td colspan="4">3.4</td><td colspan="5"></td></tr>
<tr><td>5</td><td>2.9</td><td colspan="5">3.4</td><td colspan="7">3.9</td><td>4.5</td><td colspan="3"></td></tr>
<tr><td>6</td><td colspan="6">3.9</td><td colspan="7">4.5</td><td colspan="3">5.1</td><td></td></tr>
<tr><td>7</td><td colspan="6">4.5</td><td colspan="7">5.1</td><td colspan="4"></td></tr>
<tr><td>8</td><td colspan="6">5.1</td><td colspan="8">5.8</td><td colspan="3"></td></tr>
<tr><td>9</td><td colspan="7"></td><td colspan="8">6.5</td><td colspan="2"></td></tr>
<tr><td>10</td><td colspan="8"></td><td colspan="9">7.2</td></tr>
</table>

FABRICATION ESTIMATING STANDARDS IN DECIMAL HOURS
EXCLUDING BENDING

Add for:

1 Hole Drilled: .16

1 End Threaded .09

Black Steel **Pipe** 1" **Diam.**

PIECES OF PIPE	NUMBER OF JOINTS BRAZED/FIT & TACK																
	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
1		.32	.50		.72												
2	.50		.72			.98											
3		.98															
4				1.3				1.6									
5			1.6			2.0											
6																	
7								2.4									
8									2.9								
9												3.4					
10															3.9		

FABRICATION ESTIMATING STANDARDS IN DECIMAL HOURS
EXCLUDING BENDING

Add for:

1 Hole Drilled: .16   Black Steel **Pipe**   2" **Diam.**

1 End Threaded ________

<table>
<tr><th rowspan="2">PIECES OF PIPE</th><th colspan="17">NUMBER OF JOINTS BRAZED/FIT & TACK</th></tr>
<tr><th>0</th><th>1</th><th>2</th><th>3</th><th>4</th><th>5</th><th>6</th><th>7</th><th>8</th><th>9</th><th>10</th><th>11</th><th>12</th><th>13</th><th>14</th><th>15</th><th>16</th></tr>
<tr><td>1</td><td colspan="2">.32</td><td colspan="2">.50</td><td colspan="2">.72</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>2</td><td>.50</td><td colspan="3">.72</td><td colspan="4">.98</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>3</td><td colspan="4">.98</td><td colspan="4">1.3</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>4</td><td colspan="4">1.3</td><td colspan="5">1.6</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>5</td><td></td><td></td><td></td><td></td><td></td><td></td><td>2.0</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>6</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td>2.4</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>7</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td>2.9</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>8</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>9</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td>3.4</td><td></td><td></td><td></td><td></td></tr>
<tr><td>10</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td>3.9</td><td></td></tr>
</table>

FABRICATION ESTIMATING STANDARDS IN DECIMAL HOURS
EXCLUDING BENDING

Add for:

1 Hole Drilled: .16

1 End Threaded .09

Black Steel Pipe

3" Diam.

PIECES OF PIPE	NUMBER OF JOINTS BRAZED/FIT & TACK																
	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
1	.32	.50		.72													
2	.72				.98		1.3										
3	.98			1.3				1.6									
4	1.3			1.6					2.0								
5	1.6		2.0				2.4										
6								2.9									
7																	
8										3.4							
9												3.9					
10															4.5		

FABRICATION ESTIMATING STANDARDS IN DECIMAL HOURS
EXCLUDING BENDING

Add for:

1 Hole Drilled: .16

1 End Threaded ______

Black Steel Pipe 4" Diam.

PIECES OF PIPE	NUMBER OF JOINTS BRAZED/FIT & TACK																
	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
1	.32	.50		.72		.98											
2	.72		.98			1.3											
3	.98	1.3				1.6											
4	1.6				2.0					2.4							
5						2.4											
6			2.4				2.9										
7								3.4									
8										3.9							
9													4.5				
10																5.1	

FABRICATION ESTIMATING STANDARDS IN DECIMAL HOURS
EXCLUDING BENDING

Add for:

1 Hole Drilled: .16

1 End Threaded ______

Black Steel Pipe

5" Diam.

PIECES OF PIPE	NUMBER OF JOINTS BRAZED/FIT & TACK																
	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
1	.32	.50		.72		.98											
2	.72		.98				1.3										
3	.98		1.3			1.6			2.0								
4		1.6		2.0						2.4							
5						2.4											
6			2.4				2.9										
7								3.4									
8									3.9								
9											4.5						
10														5.1			

FABRICATION ESTIMATING STANDARDS IN DECIMAL HOURS
EXCLUDING BENDING

Add for:

1 Hole Drilled: .16   Black Steel **Pipe**   6" **Diam.**

1 End Threaded ______

PIECES OF PIPE	NUMBER OF JOINTS BRAZED/FIT & TACK																
	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
1		.50		.72	.98												
2		.98				1.3		1.6									
3		1.3			1.6				2.0								
4	1.6			2.0				2.4									
5	2.0			2.4													
6	2.4						2.9	3.4									
7																	
8										3.9	4.5						
9																	
10													5.1			5.8	

FABRICATION ESTIMATING STANDARDS IN DECIMAL HOURS
EXCLUDING BENDING

Add for:

1 Hole Drilled: .16 | Black Steel Pipe | 8" Diam.

1 End Threaded ______

PIECES OF PIPE	NUMBER OF JOINTS BRAZED/FIT & TACK																
	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
1	.50		.72		.98												
2		.98			1.3		1.6										
3	1.3		1.6				2.0			2.4							
4			2.0				2.4										
5		2.4								2.9		3.4					
6		2.9			3.4												
7								3.9									
8									4.5								
9													5.1				
10															5.8		

FABRICATION ESTIMATING STANDARDS IN DECIMAL HOURS
EXCLUDING BENDING

Add for:

1 Hole Drilled: .16

1 End Threaded .09

Galvanized **Pipe** 1" **Diam.**

PIECES OF PIPE	NUMBER OF JOINTS BRAZED/FIT & TACK																
	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
1	.18	.32		.50													
2	.32	.50		.72													
3	.50																
4	.72				.98												
5							1.3										
6								1.6									
7								2.0									
8											2.4						
9															2.9		
10																	3.4

FABRICATION ESTIMATING STANDARDS IN DECIMAL HOURS
EXCLUDING BENDING

Add for:

1 Hole Drilled: .16   Galvanized **Pipe**   2" **Diam.**

1 End Threaded .09

PIECES OF PIPE	NUMBER OF JOINTS BRAZED/FIT & TACK																
	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
1	.18	.32		.50		.72											
2	.50																
3			.72			.98											
4	.98			1.3													
5						1.6											
6								2.0									
7																	
8								2.4									
9													2.9				
10																3.4	

FABRICATION ESTIMATING STANDARDS IN DECIMAL HOURS
EXCLUDING BENDING

Add for:

1 Hole Drilled: .16

1 End Threaded .09

Galvanized Pipe

3" Diam.

PIECES OF PIPE	NUMBER OF JOINTS BRAZED/FIT & TACK																
	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
1	.32	.50			.72												
2		.72			.98												
3		.98				1.3			1.6								
4		1.3															
5				1.6	2.0												
6								2.4									
7									2.9								
8										3.4							
9													3.9				
10																4.5	

FABRICATION ESTIMATING STANDARDS IN DECIMAL HOURS EXCLUDING BENDING

Add for:

1 Hole Drilled: .16 — Galvanized **Pipe** — 4" **Diam.**

1 End Threaded ________

PIECES OF PIPE	NUMBER OF JOINTS BRAZED/FIT & TACK: 0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
1	.32	.50		.72		.98											
2	.72			.98			1.3										
3	.98		1.3				1.6			2.0							
4	1.3		1.6				2.0										
5	1.6		2.0				2.4										
6	2.0							2.9									
7									3.4								
8											3.9						
9														4.5			
10																	.51

FABRICATION ESTIMATING STANDARDS IN DECIMAL HOURS
EXCLUDING BENDING

Add for:

1 Hole Drilled: .16

1 End Threaded ______

Galvanized Pipe   5" Diam.

PIECES OF PIPE	NUMBER OF JOINTS BRAZED/FIT & TACK: 0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
1	.32	.50		.72		.98											
2	.72	.98			1.3			1.6									
3	1.3				1.6												
4	1.6							2.0	2.4								
5	2.0			2.4													
6	2.4							2.9									
7									3.4								
8										3.9							
9												4.5					
10																5.1	

FABRICATION ESTIMATING STANDARDS IN DECIMAL HOURS
EXCLUDING BENDING

Add for:

1 Hole Drilled: .16

1 End Threaded ______

Galvanized Pipe

6" Diam.

PIECES OF PIPE	NUMBER OF JOINTS BRAZED/FIT & TACK																
	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
1	.50		.72		.98												
2	.98			1.3			1.6										
3	1.3	1.6				2.0				2.4							
4	2.0				2.4					2.9							
5	2.4			2.9						3.4							
6					3.4												
7	3.4				3.9												
8						4.5											
9								5.1									
10									5.8								6.5

FABRICATION ESTIMATING STANDARDS IN DECIMAL HOURS
EXCLUDING BENDING

Add for:

1 Hole Drilled: .16

1 End Threaded ______

Galvanized **Pipe**

8" **Diam.**

PIECES OF PIPE	NUMBER OF JOINTS BRAZED/FIT & TACK: 0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
1	.50	.72		.98		1.3											
2	1.3				1.6			2.0									
3	1.6		2.0				2.4										
4	2.4				2.9						3.4						
5	2.9			3.4													
6	3.4			3.9							4.5						
7	3.9			4.5							5.1						
8	4.5			5.1													
9					5.8												
10													6.5	7.2			

C-28

APPENDIX D

TIME STANDARDS
SHIPYARD ESTIMATING ONLY

CLASS	VALUE	UTAI*	CLASS	VALUE	UTAI*	CLASS	VALUE	UTAI*	CLASS	VALUE	UTAI*
1	.02	.04	22	10.2	10.9	43	116	122	64	1310	1400
2	.08	.12	23	11.6	12.2	44	128	134	65	1480	1560
3	.18	.24	24	13.0	13.7	45	144	154	66	1660	1750
4	.32	.40	25	14.4	15.2	46	164	174	67	1850	1940
5	.50	.60	26	16.0	16.8	47	185	196	68	2050	2150
6	.72	.84	27	18.0	19.2	48	207	219	69	2300	2450
7	.98	1.12	28	20.5	21.8	49	231	243	70	2620	2790
8	1.3	1.45	29	23.1	24.5	50	256	269	71	2960	3130
9	1.6	1.80	30	25.9	27.4	51	288	308	72	3320	3510
10	2.0	2.2	31	28.9	30.4	52	328	349	73	3700	3890
11	2.4	2.6	32	32.0	33.6	53	370	391	74	4100	4310
12	2.9	3.1	33	36.0	38.3	54	415	440	75	4610	4910
13	3.4	3.6	34	41.0	43.6	55	460	485	76	5240	5580
14	3.9	4.2	35	46.0	48.9	56	510	540	77	5920	6260
15	4.5	4.8	36	52.0	54.8	57	575	615	78	6640	7010
16	5.1	5.4	37	58.0	60.7	58	655	700	79	7390	7770
17	5.8	6.1	38	64.0	67.3	59	740	780	80	8190	8610
18	6.5	6.8	39	72.0	76.8	60	830	875	81	9220	9810
19	7.2	7.6	40	82.0	87.0	61	925	970	82	10490	11160
20	8.0	8.4	41	93.0	97.9	62	1025	1075	83	11840	12510
21	9.0	9.6	42	104.0	109.4	63	1150	1230	84	13270	14030

* UTAI = UP TO AND INCLUDING

APPENDIX E

BASIC LABOR STANDARDS - PIPE FABRICATION

PIPE SIZE			1/4	3/8	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	3-1/2	4	4-1/2	[illegible]	[illegible]	[illegible]
CONRAC BENDER	SET-UP		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	MAT'L. CHANGE: .7500			DIAM. CHANGE: 1.0000		[illegible]	[illegible]	[illegible]	[illegible]
	CU	EACH BEND	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]		.0780				[illegible]	[illegible]	[illegible]	[illegible]
	CU NI & FE	EACH BEND	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	.0870		.0980		.1060	[illegible]	[illegible]	[illegible]	[illegible]
CUT BENT PIPE	CU, CU NI	EACH CUT	.0313	.0321	.0330	.0338	.0346	.0352	.0381	.0398	.0415	.0431	.0449	.0466	.0500	.0568
	CRES	EACH CUT	.0445	.0520	.0595	.0669	.0744	.0894	.1043	.1193	.1342	.1492	.1641	.1791	.2090	.2688
	STL. & GALV	EACH CUT	.0317	.0328	.0340	.0352	.0362	.0385	.0407	.0430	.0452	.0475	.0497	.0520	.0565	.0654
WASH PIPE - EACH PC.			[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	.0373		.0408		.0427	[illegible]	4.0000		
	ROSIN FILL - 20		[illegible]	[illegible]	[redacted]									.0780		
GREENLEE BENDERS	SET-UP							.0550								
	CU, CU NI	≤ 45°		.0900		.0910		.0920	.0930	.0970	.0990		.1430		.1460	[illegible]
	EACH BEND	45° ≤ 90°		.0930		.0990		.1010	.1040	.1110	.1150		.1720		.1760	[illegible]
	FE	≤ 45°		.0960		.0970		.0990	.1010	.1060	.1090		.1580		.1610	[illegible]
	EACH BEND	45° ≤ 90°			.1110			.1170	.1220	.1290	.1360		.2010		.2080	[illegible]
CUT STRAIGHT PIPE	CU, CU NI	EACH CUT	.0274	.0282	.0291	.0299	.0307	.0313	.0342	.0359	.0376	.0392	.0409	.0427	.0461	.0529
	CRES	SET-UP						.0661								
		EACH CUT						.0378					.1602	.1751	.2050	.2648
	STEEL & GALV.	EACH CUT	.0278	.0290	.0301	.0313	.0323	.0346	.0368	.0391	.0413	.0436	.0458	.0481	.0526	.0615
END PREP EACH END	CU, CU NI	#1							.0231							
	CRES	#2	.0312	.0342	.0371	.0401	.0431	.0492	.0552	.0612	.0672	.0731	.0791	.0851	.0972	.1211
		#5			.0835											
	STEEL	#6	.0916	.0946	.0975	.1005	.1035	.1096	.1156	.1216	.1276	.1335	.1395	.1455	.1576	.1815
	GALV	#3	.0309	.0344	.0380	.0414	.0450	.0520	.0590	.0660	.0730	.0800	.0871	.0941	.1081	.1362
		#4	.0369	.0422	.0477	.0531	.0585	.0695	.0804	.0913	.1021	.1130	.1239	.1348	.1565	.2001
BRAZE		EACH JOINT	.0590	.0690	.0790	.0900	.1000	.1230	.1440	.1650	.1870		.2110	.2530	.2900	.1790
FIT & TACK		EACH JOINT		.0729			.0731		.0800	.0805	.0859		.0861		.0863	
WELD EACH JOINT	TO (1)	LENGTH		.0480		.0640	.0690	.1270	√.1460	√.1950	√.1508	√.1880	√ .2260		√.2920	√.4900
	OVER (1)								.1730	.2220	.1788	.2150	.2590		.3340	.5170
								0127								
TAP									76 .0524							
CUT		EAC END				.041 .059										

DRILL TABLES

HOLE SIZE		SET-UP	1/2	1	2	3
DRILL EACH HOLE	CU	.0920	.2024	.2157	.2413	.2668
	CU NI		.2120	.2354	.2807	.3260

	PIPE [illegible]	[illegible]	[illegible]	[illegible]
DRILL EACH 1/4" → 1-1/4" Ø HOLE	CRES	.0922	.1266	.1301
	STEEL & GALV.		.1309	.1369

APPENDIX F

APPENDIX F

COMBINED LABOR STANDARDS
PIPE FABRICATION
(includes 15% PF&D)

<table>
<tr><th colspan="3"></th><th colspan="7">PIPE DIAMETER</th></tr>
<tr><th colspan="3"></th><th>1"</th><th>2"</th><th>3"</th><th>4"</th><th>5"</th><th>6"</th><th>8"</th></tr>
<tr><td rowspan="2">CONRAC BENDER</td><td rowspan="2">SET-UP</td><td>MATERIAL</td><td></td><td colspan="3">0.7500</td><td colspan="3"></td></tr>
<tr><td>DIAMETER</td><td></td><td colspan="3">1.8000</td><td colspan="3"></td></tr>
<tr><td></td><td rowspan="4">BEND, CUT, & WASH</td><td>CU</td><td></td><td>.1378</td><td>.1544</td><td>.1661</td><td></td><td></td><td></td></tr>
<tr><td></td><td>CU NI</td><td></td><td>.1288</td><td>.1344</td><td>.1381</td><td></td><td></td><td></td></tr>
<tr><td></td><td>CRES</td><td></td><td>.1667</td><td>.1901</td><td>.2123</td><td></td><td></td><td></td></tr>
<tr><td></td><td>STEEL & GALV.</td><td></td><td>.1311</td><td>.1367</td><td>.1411</td><td></td><td></td><td></td></tr>
<tr><td rowspan="2">GREENLEE BENDER</td><td rowspan="2">SET-UP & BEND</td><td>CU, CU NI</td><td>.1520</td><td>.1560</td><td>.1660</td><td>.1700</td><td>.2500</td><td>.2540</td><td></td></tr>
<tr><td>FE</td><td>.1660</td><td>.1720</td><td>.1840</td><td>.1910</td><td>.2790</td><td>.2860</td><td></td></tr>
<tr><td rowspan="4">MECHANIC</td><td rowspan="4">A. CUT, END PREP & INSPECT</td><td>CU, CU NI</td><td>.1280</td><td>.1290</td><td>.1340</td><td>.1370</td><td>.1410</td><td>.1440</td><td>.1510</td></tr>
<tr><td>CRES</td><td>.1730</td><td>.1970</td><td>.2210</td><td>.2450</td><td>.3970</td><td>.4510</td><td>.5590</td></tr>
<tr><td>STEEL</td><td>.2490</td><td>.2530</td><td>.3070</td><td>.3280</td><td>.3480</td><td>.3690</td><td>.4070</td></tr>
<tr><td>GALV.</td><td>.1580</td><td>.1900</td><td>.2710</td><td>.3160</td><td>.3600</td><td>.4170</td><td>.5130</td></tr>
<tr><td></td><td rowspan="2">B. EACH JOINT</td><td>BRAZE</td><td>.0790</td><td>.1230</td><td>.1650</td><td>.2110</td><td>.2530</td><td>.2900</td><td>.3790</td></tr>
<tr><td></td><td>FIT & TACK</td><td colspan="2">.0731</td><td>.0805</td><td colspan="4">.0862</td></tr>
<tr><td></td><td colspan="2">C. EACH OPENING - CAP & TAPE</td><td colspan="5">.0200</td><td colspan="2">.0280</td></tr>
<tr><td></td><td rowspan="3">D. DRILL - EACH HOLE</td><td>CU, CU NI</td><td colspan="7">.2706</td></tr>
<tr><td></td><td>CRES</td><td colspan="7">.1500</td></tr>
<tr><td></td><td>STEEL & GALV.</td><td colspan="7">.1570</td></tr>
<tr><td></td><td colspan="2">E. THREAD - EACH END</td><td colspan="3">.0870</td><td colspan="4"></td></tr>
</table>

APPENDIX G

SAMPLE WORK SHEET
CLASSIFICATION CALCULATIONS

PCS. OF PIPE	NO. OF MADE-UP JOINTS	PIPE DIAM.: CAP/TAPE AVG. NO.	CAP/TAPE HOURS	1": HOURS EACH PIECE + JOINT	1": HOURS + CAP	1": CLASS	2": HOURS EACH PIECE + JOINT	2": HOURS + CAP	2": CLASS	3": HOURS EACH PIECE + JOINT	3": HOURS + CAP	3": CLASS	4": HOURS EACH PIECE + JOINT	4": HOURS + CAP	4": CLASS	5": HOURS EACH PIECE + JOINT	5": HOURS + CAP	5": CLASS
1	0	2	.04	.13	.17	3	.13	.17	3	.13	.17	3	.14	.18	3	.14	.18	3
	1	3	.06	.21	.27	4	.25	.31	4	.30	.36	4	.35	.41	5	.39	.45	5
	2	3	.06	.29	.35	4	.38	.44	5	.46	.52	5	.56	.62	6	.65	.71	6
	3	5	.10	.37	.47	5	.50	.60	5	.63	.73	6	.77	.87	7	.90	1.00	7
	4	6	.12	.45	.57	5	.62	.74	6	.79	.91	7	.98	1.10	7	1.15	1.27	8
	5	7	.14	.53	.67	6	.75	.89	7	.96	1.10	7	1.20	1.34	8	1.41	1.55	9
3	0	6	.12	.38	.50	5	.39	.51	5	.40	.52	5	.41	.53	5	.42	.54	5
	1	6	.12	.46	.58	5	.51	.63	6	.57	.69	6	.62	.74	6	.67	.79	6
	2	6	.12	.54	.66	6	.64	.76	6	.73	.85	7	.83	.95	7	.93	1.05	7
	3	6	.12	.62	.74	6	.76	.88	7	.90	1.02	7	1.04	1.16	8	1.18	1.30	8
	4	6	.12	.70	.82	6	.88	1.00	7	1.06	1.18	8	1.25	1.37	8	1.43	1.55	9
	5	6	.12	.78	.90	7	1.01	1.13	8	1.23	1.35	8	1.47	1.59	9	1.69	1.81	10
	6	6	.12	.85	.97	7	1.13	1.25	8	1.39	1.51	9	1.68	1.70	9	1.94	2.06	10
	7	7	.14	.93	1.07	7	1.25	1.39	8	1.56	1.70	9	1.89	2.03	10	2.19	2.33	11
	8	8	.16	1.01	1.17	8	1.37	1.53	9	1.72	1.88	10	2.10	2.26	11	2.44	2.60	11
	9	9	.18	1.09	1.27	8	1.50	1.68	9	1.89	2.17	10	2.31	2.49	11	2.70	2.88	12

APPENDIX G

APPENDIX H

APPENDIX H

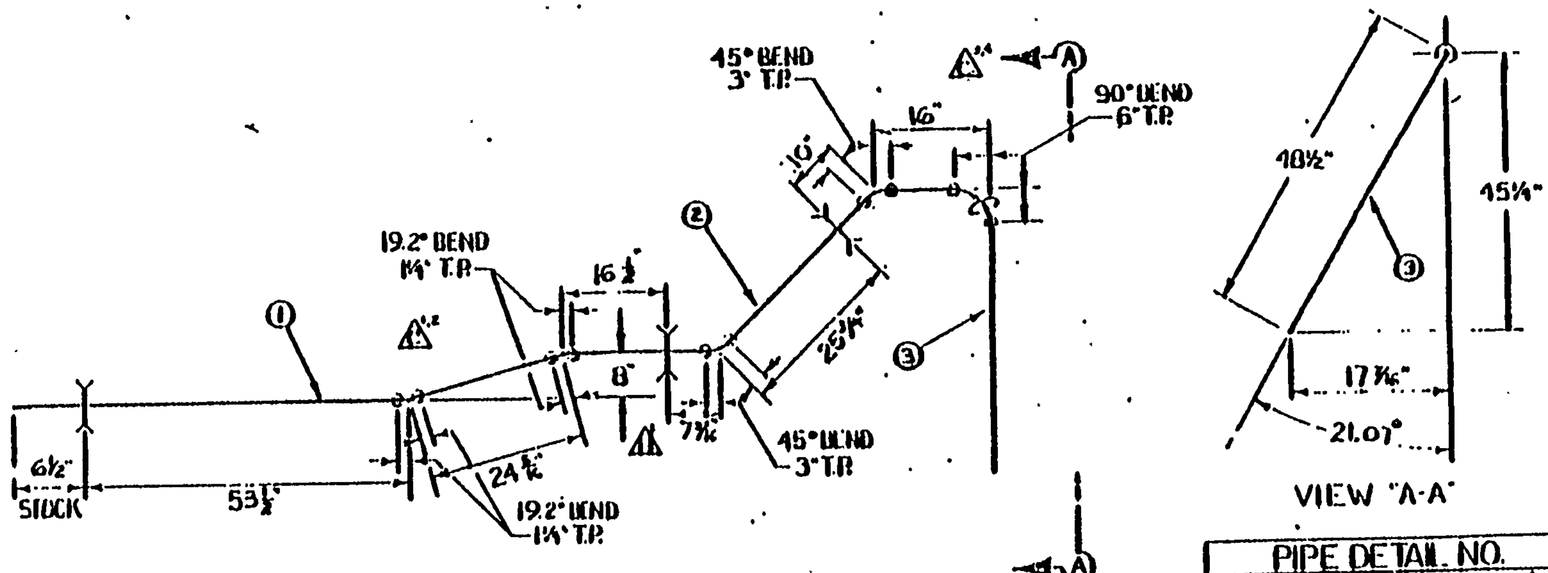
CLASSIFICATION SYSTEM TEST
WORK ORDER COMPARISON

WORK ORDER NUMBER	NUMBER OF PIPE DETAILS	ORIGINAL PSI ESTIMATE (HOURS)	LABOR STANDARD		% CHANGE CLASSIFICATION FROM DETAIL
			FROM DETAIL STANDARDS	FROM CLASSIFICATION (DEC. HRS.)	
541-023	1	4	.26	.27	+ 3.85
261-023	5	5	1.47	1.72	+ 17.01
529-021	8	32	9.73	9.82	+ 5.59
506-023	21	24	16.99	18.97	+ 11.65
514-021	25	30	30.08	33.62	+ 11.77
593-021	31	16	21.62	22.76	+ 5.27
528-024	37	60	25.75	27.98	+ 8.66
256-020	66	400	95.66	102.66	+ 7.32
TOTALS	194	571	201.56	217.80	+ 8.06

APPENDIX I

PETERSON BUILDERS INC.
SUPPLEMENTARY INSTRUCTION SHEET

CONTRACT NO. 9133
S.I.S. NO. 176-C

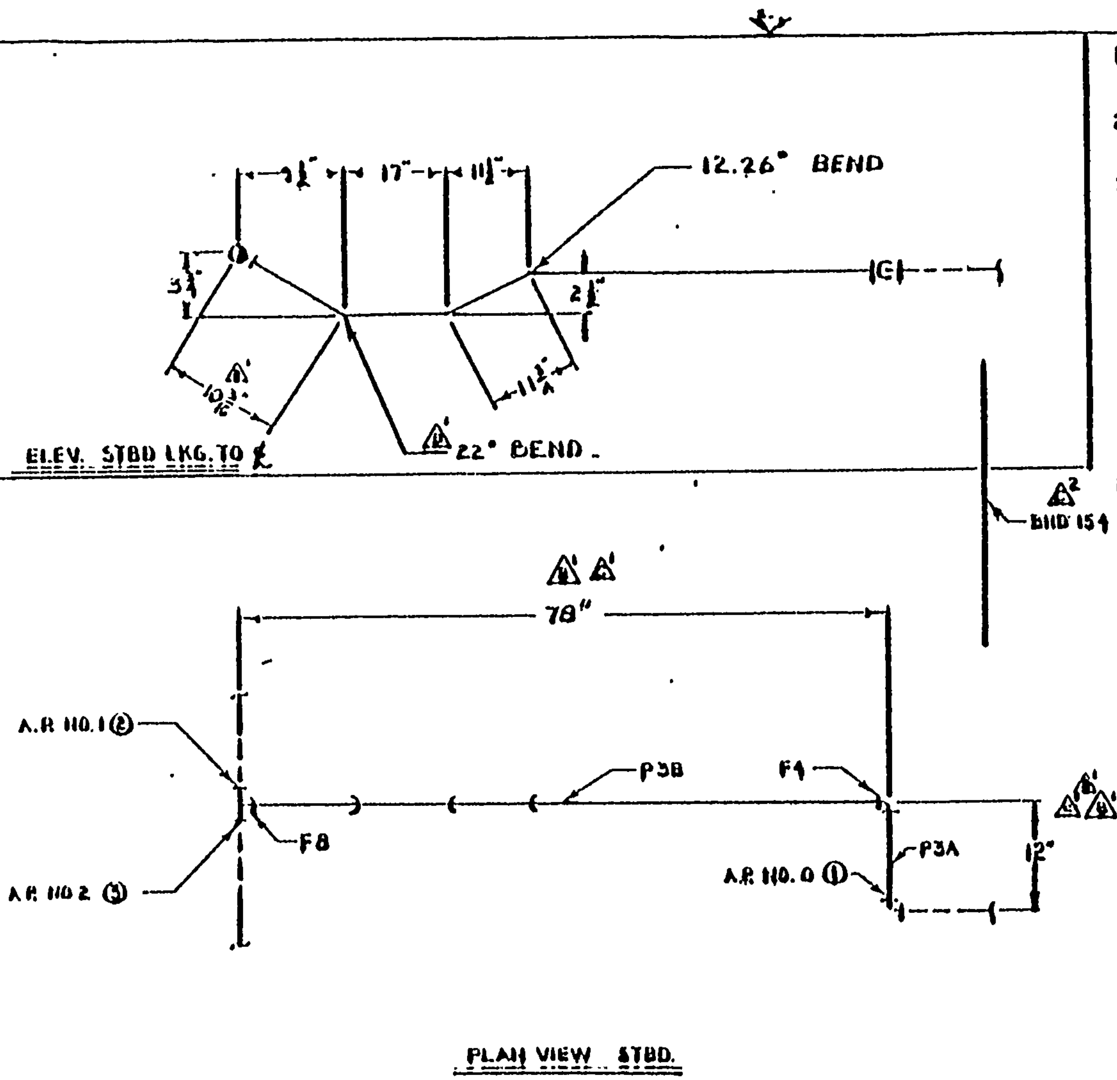


PIPE DETAIL NO.	
1	9133-541-54,5m ACM/PI
2	,5m ADB/PII
3	,5m ACD/P-II

UNDEVELOPED LENGTH	MATERIAL
17'-4 5/8"	3" IPS SCH. 40 PIPE, CRES

INSPECTION REQUIREMENTS

PROPER MATERIAL	☐ ______	HYDRO OR AIR SOAP TEST	☐ ______
DIMENSIONS & ANGLES	☐ ______	CLEANLINESS (PICKLE-FLUSH)	☐ ______
FIT-UP	☐ ______	IDENTIFICATION OF ASSY.	☐ ______
WELDING/BRAZING	☐ ______	PREPARED FOR SHIPMENT	☐ ______
END PREPARATION	☐ ______	OPEN ENDS PLUGGED	☐ ______



1. A.P. NO.(0) IS CONN. TO A.P. NO.(1) ON SPOOL NO. 9433-536-AAC
2. A.P. NO.(2) IS CONN TO A.P. NO.(0) ON SPOOL NO. 9433-536-AAE
3. A.P. NO.(3) IS CONN TO A.P. NO.(0) ON SPOOL NO. 9433-536-AAF

PC NO	QTY	DESCRIPTION	PC
F8	1	TEE RED 1½" × ½" × 1½" SB BRZ.	
F4	1	1½" 90° ELL. SB BRZ.	
P-3B	90¼"	1½" PIPE .072 WALL 90-10 CuNi	
P-3A	9¼"	1½" PIPE .072 WALL 90-10 CuNi	●

SPOOL NO. 9433-536-AAD-REV D

DRWG. NO. 9433-536-064-REV. J

W.O. NO.

SHEET 1 OF 1 | P01